Some Potential Benefits of Using Cost as an Independent Variable in Defense Programs

A Step in a Different Direction

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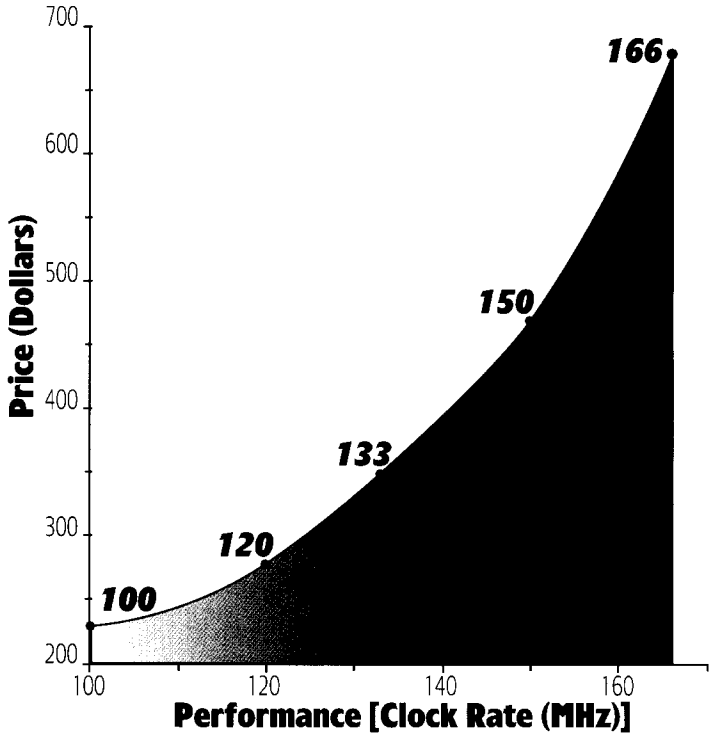
Over the past three decades, a wide variety of defense programs have been developed and deployed. Persistent and widespread cost and schedule growth in U.S. military systems has been documented since the 1950s, while system performance is typically very close to desired levels. This is despite several different acquisition strategies and numerous detailed management approaches that have been tried in an attempt to improve the predictability and control of program outcomes.

A Step in a Different Direction

Military hardware development programs typically experience moderate cost and schedule growth when actual values following completion of the development phase are compared to earlier estimates near the start of Engineering and Manufacturing Development (EMD). Evaluation of a large sample of Department of Defense (DoD) programs, indicates a large percentage of programs (80+ percent) with cost or schedule growth, and on average, a moderate level of cost and schedule growth for each program; even in the EMD phase (25 percent).[1] Furthermore, no significant change in cost or schedule growth has occurred versus time from the 1960s through at least the early 1990s.

Figure. **Microprocessor Price Versus Performance**



The numerous acquisition reforms and management improvements that have been implemented on defense programs since the 1960s have no doubt helped to contain cost and schedule growth. However, they have generally not effectively addressed impacts resulting from an acquisition process that has often been focused on system performance, with less importance on cost and schedule. The recent (1995) OSD cost as an independent variable (CAIV) initiative takes a step in a different direction – it attempts to address several key issues that can lead to increased program cost and schedule.

In the remainder of this article I discuss some typical issues that contribute to cost and schedule growth in defense programs and how the OSD

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CAIV initiative can reduce the impact of them.

Some Issues that Increase Defense Program Cost and Schedule

Some typical contributors to military development program cost and schedule growth are:

- a performance-dominated requirements specification process that begins early and is rigidly maintained through much of the development;
- a development process that is performance-driven;
- a design that is near the feasible limit of performance that can be achieved at a given time;
- uncertain and optimistic assessment of the feasible limit of performance that can be achieved in a design for a given cost and schedule; and
- major program design decisions being made before the relationship between cost, performance, and schedule (C,P,S) is understood.[2]

The common thread running through these problem areas is that the design is "pushed" in the direction of increased performance, which often translates into unexpectedly higher levels of program cost, schedule, and risk. By the time these difficulties are identified, limited design flexibility often exists, and resulting workarounds further impact program cost and schedule. (Other issues can impact program cost and schedule outcomes, which are not discussed here due to space constraints. For example, an inadequate budget and schedule may exist for the desired level of performance when the program is initiated.)

Each of the five items mentioned above generally contributes to:

- overoptimism in establishing and estimating adequate program cost and schedule levels for the desired performance;
- underestimation of cost and schedule risk; and
- an eventual increase in program cost and schedule during the development phase.[3]

The following paragraphs illustrate how several of these factors can lead to increased program cost and schedule through an unrealistic design. (This design could, hypothetically, result from performance-dominated requirements specification or a development process that favors performance.)

Price versus performance data were collected for a common microprocessor from a vendor in April 1996 and are plotted in the Figure accompanying this article. The circuit price varied solely with a single measure of performance—microprocessor clock rate (speed in megahertz [Mhz]). In this case, the last 11 percent of performance (150 to 166 MHz clock rate) leads to a 45-percent increase in processor price ($469 to $678 dollars). If the development phase design is near the upper limit of achievable performance (166 MHz here), then significant increases in development and/or production phase cost and/or schedule can result from a small increase in performance. In addition, designs below or to the right of the curve are infeasible at a given point in time. (Designs above or to the left of the curve are feasible but inefficient.)

For this example, had the original design included a 166-MHz processor with a $469 price, the resulting design would have been infeasible and required an increase in price (to $678), a decrease in performance (to 150 MHz), or some combination of these two adjustments to be on or above the curve and become feasible. This is indicative of a design with an uncertain and optimistic assessment of the level of performance that can be achieved. However, since confident relationships between cost or schedule versus performance (as in the Figure) are generally unknown until well into the development process, setting an overly aggressive level of design performance can substantially increase program risk. (Similar cost versus performance relationships exist for a variety of commercial and military prototypes, production items, items at higher levels of integration, e.g., a sensor, and often entire development programs.)

The following paragraphs discuss how DoD policy on CAIV can potentially help to reduce program cost and schedule by addressing the five issues mentioned above.

Requirements Specification

A principal part of OSD CAIV policy is "a far stronger user role in the process through participation in setting and adjusting a program's goals throughout the program, particularly in the cost-performance trade-off process."[4] Warfighter requirements should be met, but through the use of performance rather than requirements specifications, allowing the trade-off of design parameters and features versus cost.[5] In addition, program managers, "will be empowered to authorize performance or engineering and design changes as long as the threshold values in the Operational Requirements Document (ORD) and Acquisition Program Baseline (APB) can be achieved."[6] Finally, "cost objectives shall be set to balance mission needs with projected out-year resources."[7]

This aspect of CAIV policy has the potential to insure more realistic and effective requirements via greater user participation and the ability to trade off most requirements. It also has the potential to decrease program cost (and possibly schedule) by using performance rather than requirements specifications and balancing mission needs versus program cost objectives.

Performance-driven Development Process

Another key part of OSD CAIV policy is that cost should be a major driver[8] and must be viewed as an independent variable.[9] In addition, "the CAIV approach formalizes the process for cost-performance trade-off and better connects the user, supporter, and developer to facilitate effective trade-

offs, arriving at an affordable balance among performance and schedule."[10] Similarly, the "CAIV approach facilitates the process of making trade-offs among performance, schedule, and costs."[11] Likewise, DoDD 5000.1 states that "acquisition managers shall establish aggressive but realistic objectives for all programs and follow through by trading off performance and schedule, beginning early in the program (when the majority of costs are determined), to achieve a balanced set of goals."[12]

This aspect of CAIV policy clearly specifies the need for cost to be a major driver, an independent variable and part of a balanced trade process with performance and schedule. It also has the potential to decrease program cost (and possibly schedule) by eliminating performance-driven development.

Less Stressing Designs

Another aspect of CAIV policy is that techniques should be considered that have the potential to reduce cost risk and cost by moving the design away from the infeasible region of the cost-performance relationship, as well as the steep portion of this curve. This can be accomplished by a number of techniques, including the potential use of:

- design simplification to reduce complexity;
- mature manufacturing processes to increase yield and decrease cost; and
- improved technology to reduce cost.[13]

(Design simplification was used extensively in the former Soviet Union to yield designs away from the near vertical portion of the cost-performance feasibility curve.[14])

This aspect of CAIV policy suggests solution points be moved away from the steep portion of the cost-performance curve, let alone the infeasible region. The resulting design can potentially have noticeably lower cost and schedule for a minor decrease in performance.

Uncertain and Optimistic Designs

Another aspect of CAIV policy relates to the level of risk associated with designs. Dr. Kaminski's December 4, 1995 memo states: "Risks in achieving both performance and aggressive costs goals must be clearly recognized and actively managed through continuing iteration of cost/performance/schedule/risk trade-offs, identifying key performance and manufacturing process uncertainties, and demonstrating solutions prior to production."[15]

This CAIV tenet has the potential to reduce over-optimism in setting the design, which can eventually lead to decreased program cost and schedule, by requiring that risks be recognized, administered through a proactive risk management process, and requiring viable risk mitigation activity.

Major Project Decisions Occur Before C,P,S Relationship Understood

Another key aspect of CAIV is that aggressive and realistic cost objectives are to be set early in the program (Concept Development of Demonstration/Validation phase).[16] In addition, "the government should apply the results of cost/performance trade-offs in contracts early in the process, preferably before down-selection."[17] Similarly, acquisition managers shall "establish aggressive but realistic objectives for all programs and follow through by trading off performance and schedule, beginning early in the program (when the majority of costs are determined)."[18]

This CAIV tenet has the potential to reduce program cost by having the cost-performance trade process begin early in the development phase, thus reducing the odds that unforeseen problems (e.g., due to an infeasible design) will occur later in the program when potentially large increases in cost and schedule may result.

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